ATTACHMENT C
ETHANOL DEMAND AND SUPPLY ANALYSIS

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INTRODUCTION

This analysis of future California demand and supply for "fuel alcohol" markets in 2010, 2020 and 2030 builds from an existing U.S. domestic ethanol production industry. The two California markets examined include ethanol used to make California Phase 3 Reformulated Gasoline (CaRFG3) and ethanol blended at higher volumes (E85 or E40) for use in Flexible Fuel Vehicles (FFVs), vehicles specifically designed to use variable ethanol content up to 85 percent by volume with gasoline. Option 2F (Alcohol Fuels in Flexible Fuel Vehicles) and Option 2G (Use of Ethanol in California Reformulated Gasoline) are two petroleum reduction scenarios that would give rise to this potential demand in future years.[1]

A basic question regarding ethanol supply in 2010, 2020, and 2030 can be stated as follows: "If Options 2F and 2G were implemented as the sole petroleum reduction options in the 2010 to 2030 timeframe, does analysis show adequate supplies of ethanol to meet the demand?" The short answer to the question is "Yes."[2]

FINDINGS SUMMARY

The major findings of the analysis appear in Table C-1. Demand is based on the assumption that California drivers of on-highway cars and light trucks would use E85 fuel in a growing population of FFVs, and that E10 CaRFG3 is used in the balance of non-FFV light duty vehicles. Supply sources include California, U.S. domestic, as well as ethanol produced in other countries. Though not shown in this table, in-state ethanol production supplies 62, 76 and 86 percent of the in-state ethanol demand (E10 and E85) in 2010, 2020,and 2030, respectively, under aggressive development of an in-state ethanol production industry. The analysis also shows that should an E40 (40 percent ethanol) FFV fuel[3] replace E85 as the preferred fuel, then the in-state production could supply all California ethanol demand in 2020 and satisfy the 2030 demand with an excess of about 840 million gallons.[4] Ethanol from outside of California would be needed to meet the 2010 demand (E10 and E40), as well as 2010, 2020, and 2030 demands for the E10 and E85 combination.

Table C-1. Ethanol Supply and Demand Summary (billion gallons/year)

	2010	2020	2030
All Ethanol Supply Sources	8.43	18.67	29.12
Ethanol Demand (E10 and E85)	1.745	3.085	4.579
Demand (percent of supply)	20.7%	16 .5%	15.7%

CONCLUSION SUMMARY

A combination of in-state production combined with imports of ethanol from the Midwest and foreign sources can provide California with adequate supplies of ethanol to meet an aggressive demand scenario through the year 2030, even with the absence of implementation of other AB 2076 petroleum reduction options.

ETHANOL DEMAND ANALYSIS

Petroleum displacement options 2F and 2G imply potentially significant use of ethanol through the year 2030 and beyond the base case ethanol demand associated with the use of 5.7 volume percent ethanol in CaRFG3. Option 2F implies additional demand for ethanol since this option assumes high ethanol content fuel use in Fuel Flexible Vehicles (FFVs). As FFVs are phased into use, staff assumes that various federal, state, or local inducements to consumers result in the use of E85. Staff also assumes the emergence of a more optimal "FFV fuel" containing a lower percentage ethanol and priced by oil companies at retail outlets to induce use and compete with or replace other gasoline formulations.[5]

Table C-2 summarizes ethanol demand for the chosen scenario options involving combinations of E10, E85, and "FFV fuel" (a nominal 40 percent ethanol fuel) in 2010, 2020, and 2030. As Table C-2 shows, ethanol use in E10 dominates the demand in 2010 and 2020. Ethanol demand for E85 peaks in 2030 at 2.59 billion gallons, or 57 percent of the total ethanol demand in that year. If "FFV fuel" (E40) became the preferred fuel, then FFVs would use 35 percent of the ethanol supplied to the California on-road light duty vehicle fleet in 2030.

Table C-2. Potential Ethanol Demand by Fuel Type (billion gallons/year)

Fuel Type	Volume of Fuel that is Ethanol		
	2010	**2020**	**2030**
1) E10	1.711	1.849	1.990
2) E85	.034	1.236	2.589
3) E40 (FFV Fuel)	.015	.521	1.090
Demand Case #1 (1 plus 2)	1.745	3.085	4.579
Demand Case #2 (1 plus 3)	1.726	2.370	3.080

Staff has assumed that FFVs not using E85 or FFV fuel use E-10 fuel in the balance of gasoline vehicles. That is, in any year, all light duty vehicles use one of these three fuels as non-FFV motor vehicles have switched to E10 in 2008. The number of FFVs in this analysis is constrained to follow the vehicle fuel use assumptions in the Option 2F analysis. Ethanol demand for E10 is consistent with Option 2G assumptions with the exception that E10 use has been reduced consistent with use of E85 or FFV fuel use in Option 2F FFVs. FFVs are assumed to penetrate the fleet and start using E85 by 2008. Annual E85 or FFV fuel use rises rapidly from 2010 to 2020 and tracks overall fleet growth from 2020 to 2030. In 2010, 40,000 FFVs use these fuels full time. By 2030, 3,969,000 FFVs use the fuels out of a total population of 35,436,000 or 11.2 percent of the vehicle fleet.

Demand Case #1 in Table C-2 was chosen as the target demand for this analysis since it represents the more aggressive demand that might be limited by supply considerations.

ETHANOL SUPPLY

Staff assumed supplies of ethanol for California will come from several sources through 2030. In the near term, the midwest states will continue to provide the majority of ethanol used in CaRFG whether E5.7 or E10. Some ethanol will come from the Pacific Northwest and other regions of the United States.

- California will create its own in-state ethanol production industry over time thus decreasing the required level of imported ethanol over the analysis period.

- Ethanol supplies from North American Free Trade Agreement (NAFTA) partners, Caribbean Initiative countries, Brazil and other international sources will emerge.

- Ethanol produced from waste biomass and purpose grown "energy" crops will emerge as a result of continuing federal R & D for emerging cellulosic conversion technologies and state support to implement use of the technology in commercial production facilities in and outside of California.

Table C-3 summarizes anticipated supplies from these sources. Each of these supply sources is covered in more detail in the following paragraphs.

Table C-3. Summary of Ethanol Supply Sources and Volumes (billion gallons/year)

Sources of Ethanol	**2010**	**2020**	**2030**
Midwest (conventional and cellulosic)	6.37	14.37	22.27
California (conventional and cellulosic)	1.09	2.36	3.92
Foreign (conventional)	0.97	1.94	2.93
Total Supply	8.43	18.67	29.12
Demand Cases			
Demand Case #1	1.745	3.085	4.579
Demand (as a percent of supply)	20.7%	16.5 %	15.7%
Demand Case #2	1.726	2.370	3.080
Demand (as a percent of supply)	20.5%	12.7%	10.6%

Midwest Sources of Ethanol. Staff assumes that the proposed federal Renewable Fuel Standard (RFS) under discussion in Congress will be passed into law soon, and that MTBE will be banned nationwide. The RFS will require five billion GPY renewable fuels use by 2013. Staff further assumes that most of this volume will be produced in the Midwest with smaller contributions from the Pacific Northwest and other regions. A separate DOE report projects a growth in renewable fuels use in 2002 from 1.9 billion GPY today to 8.8 billion GPY in 2016.

Further assuming an estimated 85 percent ethanol and 15 percent other renewable fuel use as suggested in the DOE report, new ethanol production capacity of about 390 million gallons each year will be required to achieve the projected 2016 ethanol use. To achieve this growth, about 10 new ethanol plants would need to be constructed every year (each with a capacity of 40 million gallons per year). This appears to be within the capabilities of the industry. The

December 2002 update of the California Energy Commission's survey of the ethanol industry shows ethanol production capacity growing at about 650 million gallons per year over the 2003 to 2005 period. Staff further assumed that this growth would remain constant through 2030 yielding conventional grain based ethanol volumes as shown in Table C-4. We start with a capacity of 2.3 billion gallons per year and discount it 15 percent for beverage and industrial ethanol markets in 2002. This growth in capacity is only half of what is projected over the next several years in the U.S. to meet anticipated ethanol demand as a result of MTBE phase-out needs in California, thus, a conservative assumption relative to near term U.S. growth rates in ethanol production.

Table C-4. Midwest Fuel Ethanol Production Capacity (billion gallons/year)

Source of Ethanol	2010	2020	2030
Conventional grains	5.47	9.37	13.27
Cellulose (non-Calif/PADD5)	0.90	5.00	9.00
Total Supply	6.37	14.37	22.27

Table C-4 also includes cellulose-based ethanol production, derived from the conversion of corn stover primarily, and smaller contributions from energy crops, and other waste biomass resources. Staff assumed that DOE sponsored research and development and partnerships with industry will stimulate growth of cellulose-based ethanol substantially by 2020, and that cellulose-based ethanol reaches 5.0 billion gallons by 2020. This volume is consistent with estimated volume (excluding the California volume) in the DOE ethanol infrastructure study performed by Downstream Alternatives, Inc.[6] Staff chose the DAI growth rate (PADD 5 excluded) of 4 billion gallons of cellulose-based ethanol over 10 years to establish the 2030 value of 9 billion gallons per year cellulose-based ethanol production in all states except California.

California Ethanol Supply. Staff assumed that California would become an ethanol producing state prior to 2010. California would create an incentive program similar in some respects to state programs existing today in the Midwest. However, in contrast to other states, California's unique and varied mix of agricultural crops, supporting infrastructure and diverse biomass resources creates opportunities for some ethanol production likely not requiring incentives from the state. Staff assumed that about 200 million gallons of ethanol production capacity would be supplied from facilities able to secure conventional financing and showing favorable production economics. Beyond this, staff assumed that some form of California incentive program would be required to support an emerging in-state waste biomass-to-ethanol industry and expand opportunities for additional conventional starch/sugar based production facilities.

Before 2010, staff assumed that in-state ethanol will be derived primarily from conventional starch and sugar resources (corn, sugar cane, sorghum, sugar beets, barley and others). Staff further assumed that conventional starch/sugar facilities would allow for the integration of cellulose processing equipment once the technology matures. These facilities would increase their capacity to improve the economics of California ethanol production knowing that corn-stover to ethanol conversion technology that will be integrated into Midwest corn-to-ethanol dry mill production facilities beginning in the 2008-2010 timeframe.

By 2020 cellulose-based ethanol from forest, agricultural and urban wastes becomes a significant source of the in-state ethanol production (carrying on through 2030) based on anticipated advances in conversion technology and large-scale commercial implementation. Staff further assumed that cellulose-based ethanol developments will largely occur in integrated fashion with conventional ethanol production as a cost cutting approach by California facilities to remain competitive with imported ethanol from the Midwest, Pacific Northwest, and other regions of the country.

Table C-5 summarizes estimated production capacity based on several additional assumptions. Staff assumed that 1.25 million acres of irrigated California agricultural land is available for conventional crops such as sugar cane, sugar beets, sorghum, corn, and other high starch or sugar sources in 2010. This acreage (about 10 percent of California croplands) represents a conservative estimate of land available on which historical but now uneconomic crops are raised.

Sugar cane, sugar beets and sorghum are assumed to be grown in the Imperial Valley on 250,000 acres devoted to these crops by 2030. The remaining one million acres in corn and other grains and energy crops are assumed to yield 500 gallons ethanol/acre annually, with growth to 3 million acres by 2030 and improved yield at 600 gallons ethanol/acre. California's forestry, agricultural, and urban cellulosic wastes are utilized at 5 percent, 20 percent and 40 percent of the long-term resource base for ethanol production in 2010, 2020, and 2030 respectively. This is based on the assumption that conversion technology and feedstock collection advancements allow economic recovery of 40 percent of California's waste biomass resources by 2030.

Table C-5. California Ethanol Production Capacity (billion gallons/year)

Source of Ethanol	2010	2020	2030
Sugar Cane (+field trash and residues)	0.40	0.50	0.60
Grains (corn, barley, wheat, sorghum)	0.50	1.10	1.80
Waste Biomass (cellulose)	0.19	0.76	1.52
Total Supply	1.09	2.36	3.92

Table C-5 illustrates that California alone can not meet the market demand tabulated in Tables C-2 and C-3 for the scenarios involving E85 use. For the FFV fuel and E10 scenario, however, in-state ethanol supplies are adequate in 2020 and 2030. The excess supply in 2030 could go to additional FFVs that would use the E40 FFV fuel in lieu of gasoline vehicles using E10 CaRFG.

Foreign (Out-of-Country) Ethanol Supplies. Table C-6 summarizes foreign ethanol supplies. In this analysis, staff assumed that the existing federal import tariff of 54 cents per gallon on foreign produced ethanol is retained through 2030. This would preclude imports of vast volumes of potentially lower production cost foreign ethanol that might undercut the development of an emerging California in-state ethanol industry or hamper development of other U.S. domestic ethanol supplies. However, staff assumed that tariff free ethanol does flow through the Caribbean (under the Caribbean Basin Initiative) up to volumes allowed under law (7 percent of the previous year's U.S. domestic ethanol production). This amounts to additional ethanol supplies in 2010, 2020 and 2030 of 0.470, 0.940 and 1.43 billion gallons per year, respectively. Staff assumed that all the volume would come to California since CaRFG3 is assumed to be the highest value gasoline market in the United States. Staff found no evidence that many other states intend to adopt CaRFG3 specifications any time soon, thus, California is assumed to remain an isolated and large specialty gasoline market through 2030.

Table C-6. Ethanol Supply from Foreign Sources (billion gallons/year)

Countries of Origin	2010	2020	2030
Caribbean	0.47	0.94	1.43
Brazil	0.20	0.30	0.40
NAFTA Partners	0.20	0.50	0.80
Other Countries	0.10	0.20	0.30
Total Foreign Supply	0.97	1.94	2.93

Brazil at times has in excess of one billion gallons per year idle ethanol production capacity. Because the world sugar market currently drives production of ethanol from these facilities, Brazilian ethanol availability is unreliable. Staff assumed that Brazil would plant additional sugar cane and construct more flexible ethanol production/sugar processing facilities specifically to meet growing world ethanol markets. However, the U.S. import tariff will discourage importation of Brazilian ethanol even though the cost of producing ethanol from Brazilian sugar cane is low. Staff assumed 200 million gallons per year of Brazilian ethanol in 2010 growing to 400 million gallons per year in 2030. With world trade normalization and the removal of protective trade barriers, additional out-of-country ethanol would likely come to California. Staff made no attempt, however, to quantify the volumes possible in future years. Such ethanol might displace some ethanol shipped from the Midwest if the economics are favorable

Staff also assumed an additional flow of ethanol from Canada and Mexico because long-term fuel ethanol markets in California will be lucrative under favored trade status of the North American Free Trade Agreement (NAFTA). Other countries in the Pacific Rim may also deliver ethanol to California. A conservative estimate of 100, 200 and 300 million gallons per year would likely flow from Central and South American sources and perhaps Australia.

CONCLUSION

Adequate supplies of ethanol appear to be available to meet California's needs under an aggressive use scenario which involves E10 and E85 or E10 and E40 FFV fuel in all California on-road light duty vehicles. The aggressive growth of an in-state ethanol industry will keep U.S. domestic and foreign imports low in the 2020 and 2030 timeframe. By 2020, about 47 in-state ethanol production facilities, each producing about 50 million GPY, would be required to produce 2.36 billion gallons of ethanol. In 2030, 40 percent of California's annually available waste-biomass resources would be converted to ethanol supplying about 40 percent of the in-state production. The equivalent of 30 waste-biomass to ethanol facilities at 50 million GPY production could provide the cellulosic ethanol, however, preprocessing of cellulose on the front end of conventional ethanol plants may prove to be the more cost-effective option in the 2010 to 2020 timeframe.

By 2030, 3,969,000 FFVs use either E85 or E40 FFV fuel out of a total of 35,436,000 on-road light duty vehicles or 11.2 percent of the vehicle fleet. The excess supply of 840,000,000 gallons in 2030 under the E10 and E40 scenario could be used to fuel 1,325,000 additional FFVs thus increasing the size of the FFV fleet to over 5 million vehicles.

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[1] In all likelihood, several petroleum displacement options in combination with some ethanol use beyond 5.7 volume percent in CaRFG3 could be implemented in future years. Thus, the demand analysis here should be looked upon as aggressive scenario.

[2] This limiting upper bound analysis is based on several assumptions about potential supply sources, technological advances in ethanol production, R & D investment priorities and marketing efforts by oil companies to promote the use of ethanol containing fuels. Of course, other analysts using different assumptions and/or methodologies may come to alternate outcomes and conclusions. Such analyses are encouraged and sought as part of the public comment process the California Energy Commission is administering under the AB 2076 legislation.

[3] A fuel containing around 40 percent ethanol could be an "optimal" FFV fuel. An example of such a fuel can be found in an EPACT designated "substantially not petroleum" i.e. alternative fuel known as P-series (Federal Register, Vol. 64, No. 94, pp. 26822- 26829, May 17, 1999). Replicate FTP tests of this fuel in an FFV have illustrated the potential of engineered fuels to provide lower emissions when compared to E-85, conventional, and reformulated gasoline, as well as extended vehicle range (relative to E-85), comparable gasoline (energy) equivalent fuel economy (relative to gasoline) and substantial petroleum displacement.

[4] This excess supply could be used to fuel about 1,300,000 additional FFVs thus increasing the size of the California FFV fleet to over 5 million vehicles. This shift from 11.2 percent to 15 percent penetration of the 2030 on-road light duty vehicle fleet of 35.4 million vehicles could increase to higher penetrations with implementation of several efficiency and fuel substitution options examined in the AB 2076 analysis.

[5] The fuel is assumed to contain in the range of 30 to 50 percent ethanol, low value or rejected refinery blendstocks and other refinery or purchased blending components yielding a fuel competitive with oxygenated and non-oxygenated CaRFG. In this analysis, "FFV fuel" is assumed to contain 40 percent ethanol by volume. This FFV fuel (whether E-85 or E-40) is assumed to be distributed in same manner that gasoline is, i.e., through the existing and future gasoline infrastructure, including transport by pipeline.

[6] "Infrastructure Requirements For An Expanded Fuel Ethanol Industry", Downstream Alternatives Inc., 2002.